8 Delineation Tools

Several BASINS tools have been developed to assist the user with watershed delineation. The comprehensive data products included in BASINS were developed based on nationally available information and are suited for large-scale assessments. When dealing with localized small-basin analysis, however, higher-resolution data might be necessary to effectively capture the site-specific feature variability. The BASINS delineation tools are provided to assist with delineating subwatersheds. The two delineation toos and their functions are described below.

Manual Delineation Tool: This tool allows the user to delineate subwatersheds using a mouse. Doing so allows a user to segment a watershed into several smaller hydrologically connected watersheds based on the user's knowledge of that watershed's topography. *Automatic Delineation Tool*: This tool allows the user to delineate subwatersheds based on an automatic procedure using Digital Elevation Model (DEM) data. User specified parameters provide limits that influence the size and number of subwatersheds created. This tool requires the ESRI Spatial Analysis extension.

8.1 Manual Watershed Delineation

Purpose

The BASINS 3.0 *Manual Watershed Delineation* tool allows the user to subdivide a watershed into several smaller hydrologically connected watersheds for use in watershed characterization and modeling. The tool is further enhanced to provide users the flexibility in editing shapes and attributes of manually delineated watersheds, outlets and generating stream networks.

Application

A watershed boundary created using the BASINS *Watershed Delineation* tool allows a user to define the entire land area contributing to flow in a stream. The BASINS system enables a user to manually delineate watershed boundaries for analysis and modeling. This tool operates on ArcView vector data and does not require the Spatial Analyst Extension. Watersheds can be delineated for Reach File, V1 or Reach File, V3 or NHD reach file stream segments depending on which data will be used for modeling. Single watersheds or watershed systems containing multiple subwatersheds can be delineated using the BASINS *Watershed Delineation* tool. Watershed analysis can be performed on delineated watersheds using the BASINS Watershed Characterization Report tools. Sample reports include landuse distribution, point sources (PCS), water quality data, toxic chemical releases (TRI), soil distribution (STATSGO), and elevation (DEM). Watershed modeling can also be performed on a single delineated watershed or multiple watersheds using the BASINS HSPF or SWAT model.

The procedures for using the *Watershed Delineation* tool are described below for single and multiple watershed delineations. Watershed delineations procedures are the same for Reach File, V1 or Reach File, V3 or NHD reach files stream segments. However, reach file data provided for the Pacific Northwest (PNW) region of the United States is in a different format then standard Reach File, V3 data and requires special data processing to prepare the data for watershed delineation and modeling. The procedures for delineating PNW reach data are included at the end of this section.

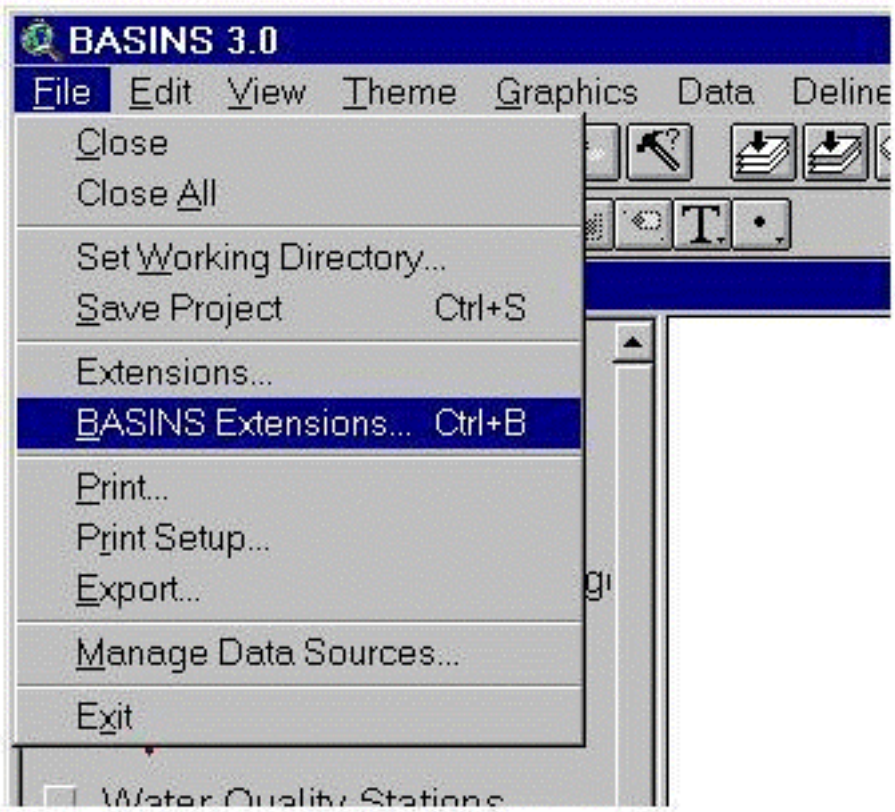
Key Procedures

- Select BASINS Extensions from the files menu
- Select Delineate under the extension category and check *Manual Watershed Delineation* as the extension category
- Activate the Cataloging Unit Boundary theme
- Select the Cataloging Unit Boundary in which to perform the delineation
- Click on the *Delineate* menu and select Manual Delineation to bring up the Manual Delineation Tools bar
- Click on the Delineate Subbasins button in the Manual Delineation Tools bar
- Select Reach File Version 1 or Version 3 or NHD reach file

- Assign a watershed name
- Create the watershed outline
- Create additional watershed outlines as needed

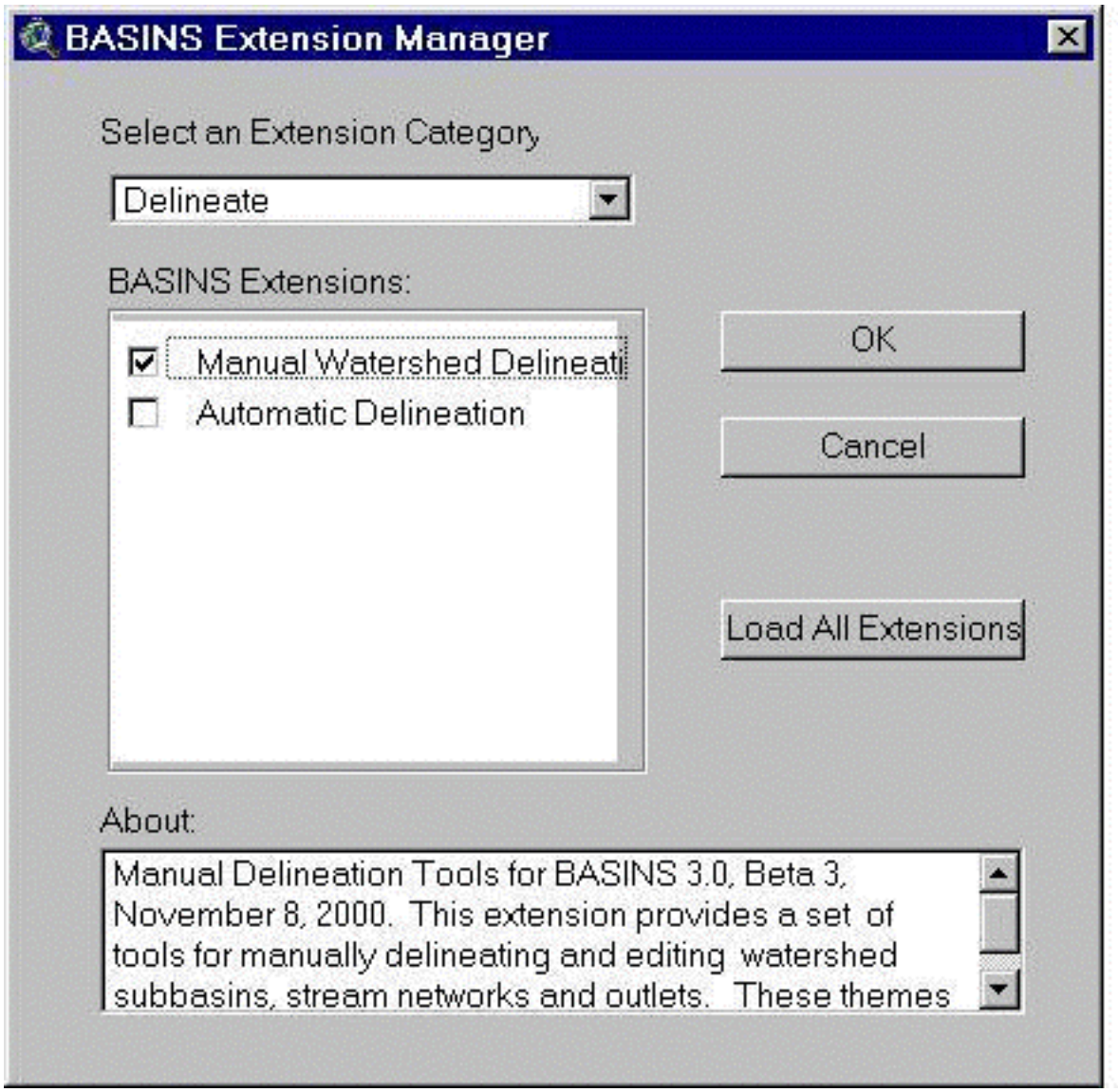
Detailed Operations

Single-Watershed Delineation Click on the BASINS Extension submenu under the Files Menu (Screen 8.1.1).



Screen 8.1.1

Select Delineate under the Extensions category and check *Manual Watershed Delineation* as the extension category. This will create a Menu under BASINS called *Delineate* under which a submenu called *Manual Delineation* will be created (Screen 8.1.2).

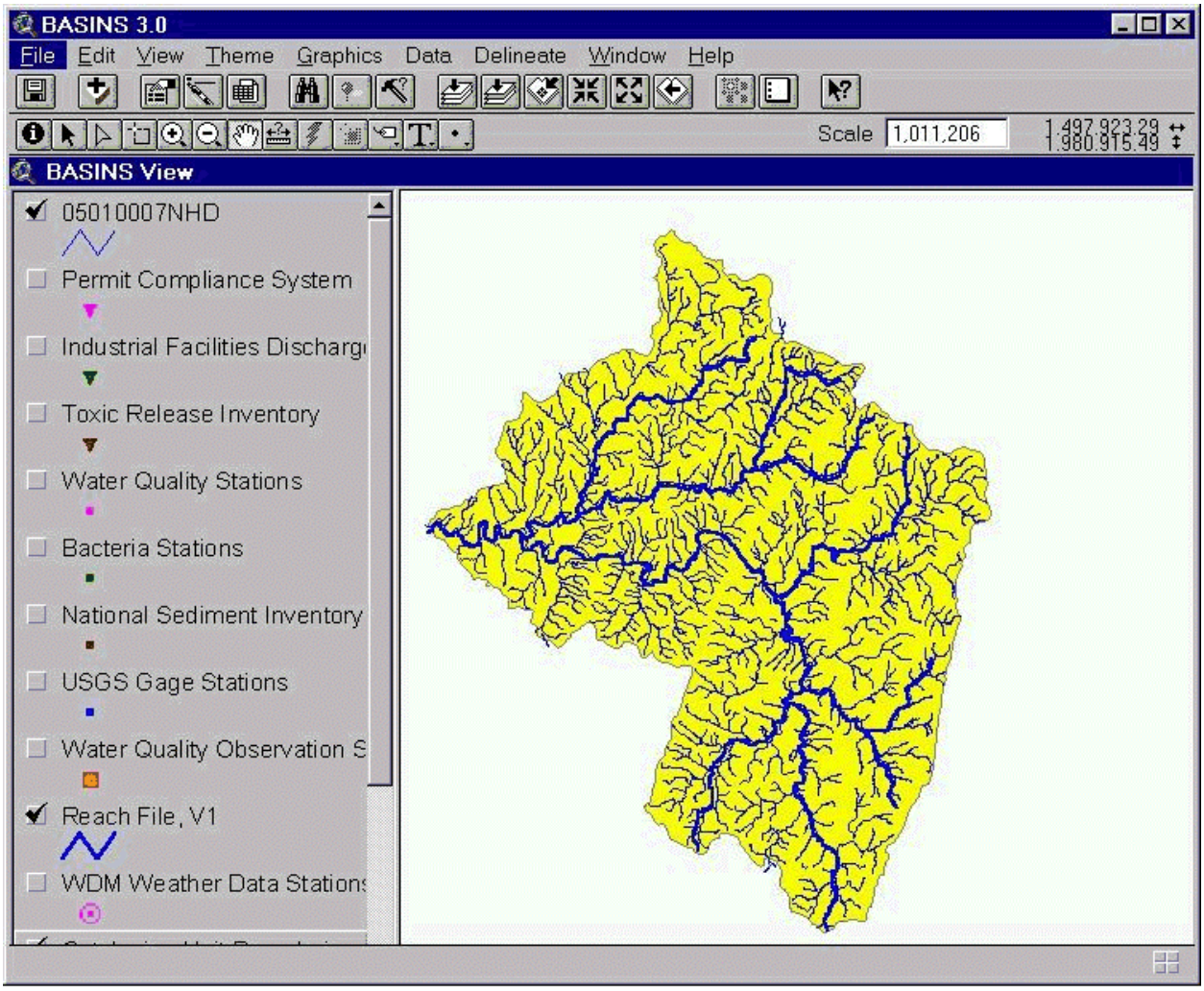


Screen 8.1.2

Turn on the Cataloging Unit Boundaries theme and Reach File, V1 or Reach File, V3 or NHD reach themes. Reach File, V3 or NHD data will need to be imported using the BASINS *Import* tool (Refer to section 7.3). If the NHD reach file is not available it can be downloaded using the NHD download tool (Refer to section 7.4). Zoom in on the area in which you wish to delineate a watershed.

Tip: It is recommended that you import and turn on the Reach File, V3 or NHD reach file and DEM (elevation) themes for your selected area. These themes are useful in defining the watershed boundaries.

Activate and display the Cataloging Unit Boundaries theme. Select the cataloging unit boundary in which the watershed delineation will be performed (Screen 8.1.3).



Screen 8.1.3

Click on the *Delineate* menu and select Manual Delineation. A Manual Delineation Tools bar will show up (Screen 8.1.4).

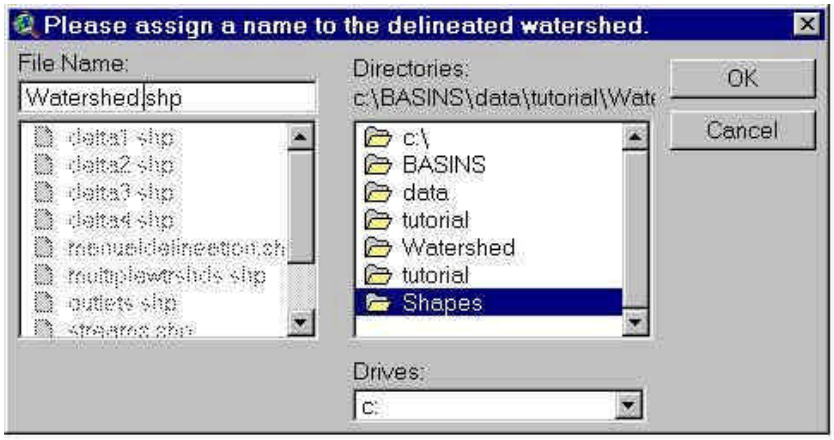
Screen 8.1.4

Click on the *Delineate Subbasin* tool button in the Manual Delineation Tools bar (Screen 8.1.4, first button)

A dialog box will prompt you to select a Reach File (Screen 8.1.5). Select "Reach File, Version 1", "Reach File, Version 3" or "NHD reach network" depending on the stream level to be used for modeling. A unique ID will be assigned to the delineated watershed.

Screen 8.1.5

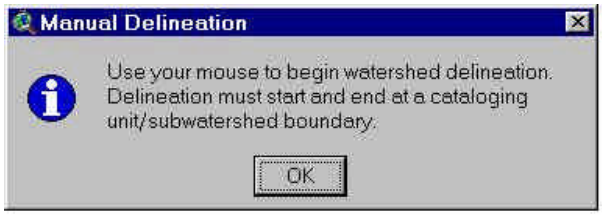
The next dialog box will prompt you: "Please assign a name to the delineated watershed" (Screen 8.1.3). At this prompt, enter a name of the watershed to be delineated (i.e. the name of the shape file to be created). Click *OK* to save file and continue. The default directory for delineated watershed boundary themes is BASINS\DATA\[PROJECT NAME]\WATERSHED\[PROJECT NAME]\SHAPES\.



Screen 8.1.6

Tip: The theme for your soon-to-be-created watershed will appear at the top of the themes list, the theme will be active, and the check box will display a check and a dashed outline. The dashed outline indicates that the theme is in edit mode and ready for watershed delineation.

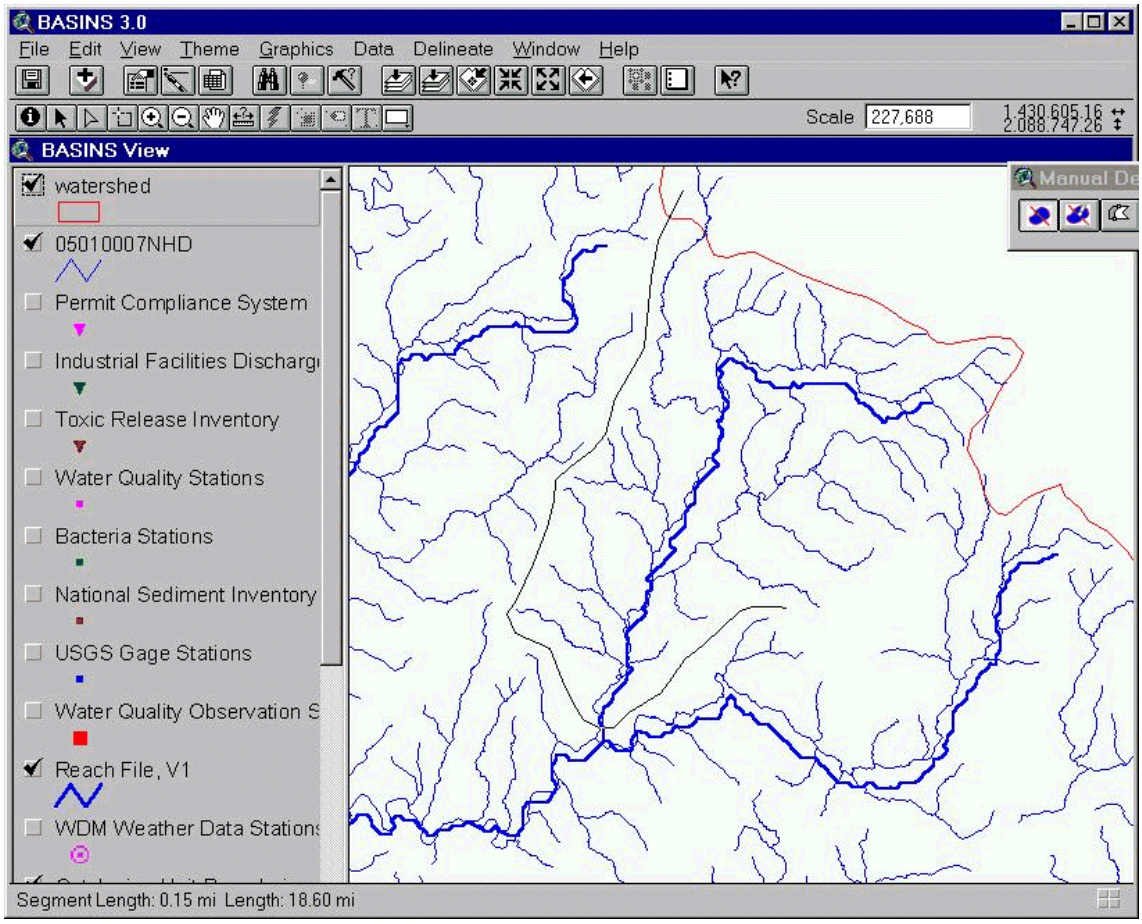
A window will prompt you to begin watershed delineation (Screen 8.1.7). Click *OK* to continue.



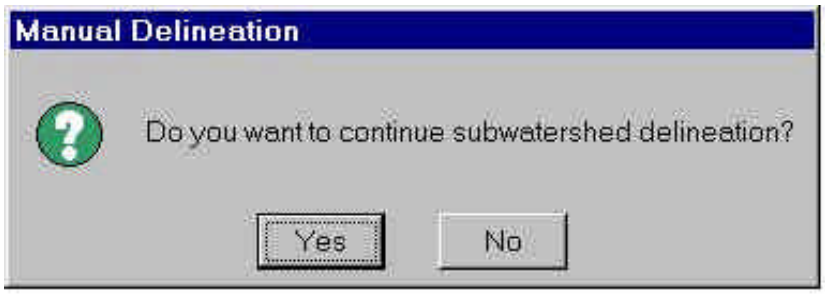
Screen 8.1.7

To delineate your watershed, you need to begin and end the delineation process at the boundary of the cataloging unit in which you are working. The cataloging unit boundary should now appear red. Place the mouse pointer slightly outside the cataloging unit boundary and click the left mouse button to begin delineation. Move the cursor to a point within the cataloging unit boundary and click the left mouse button once to create the first line segment of the watershed outline. Repeat this point-and-click process until the entire watershed outline is developed (Screen 8.1.8). Finish the watershed outline by double clicking the mouse at a point just outside the cataloging boundary. It is not necessary to delineate the portion of your watershed that coincides with the cataloging unit boundary. The delineation tool automatically clips your watershed at the cataloging unit boundary. After completing the watershed delineation, you will be asked: "Do you want to continue subwatershed delineation?" For a single-watershed delineation, Select *No* (Screen 8.1.9). A dialog box will show up asking the user to input a name of all the watersheds generated as part of the delineation. Note that a default name is provided for the watershed and the particular watershed is highlighted (e.g. Screen 8.1.10)

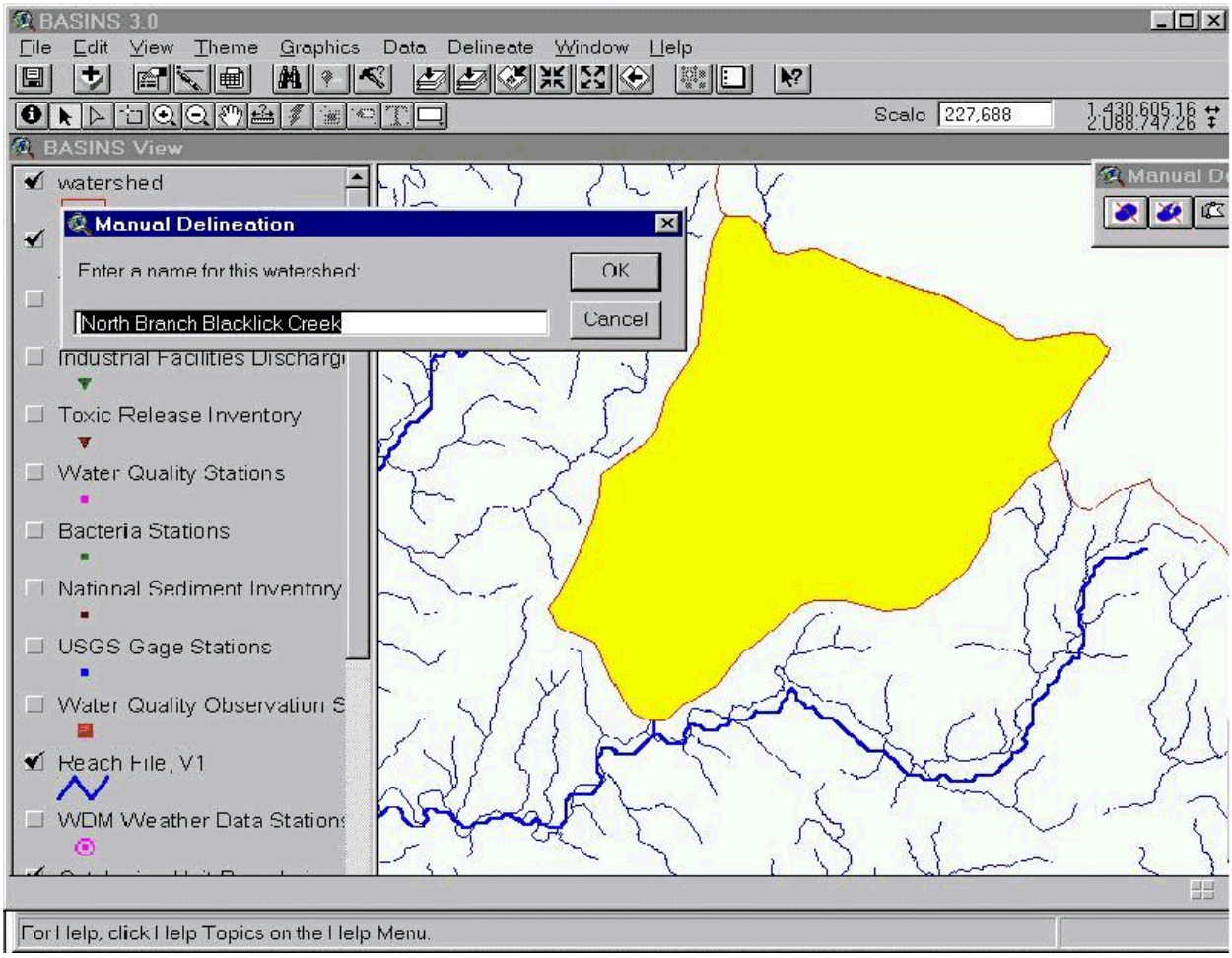
Tip:	Best results are produced by an "out-and-back" procedure; that is, delineate in the direction of the watershed's pour point (on one side of the stream segment) and return to the cataloging unit boundary on the other side of the stream. Start the watershed delineation at the upper most stream segment (headwaters) within the study area and work down stream.



Screen 8.1.8

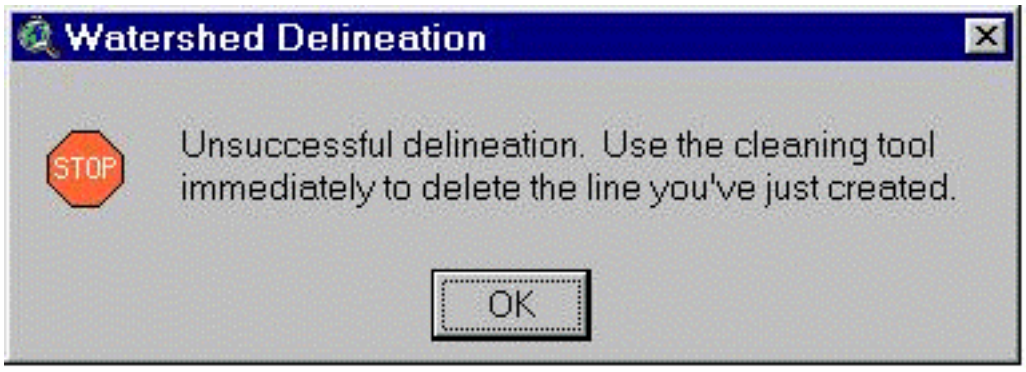


Screen 8.1.9



Screen 8.1.10

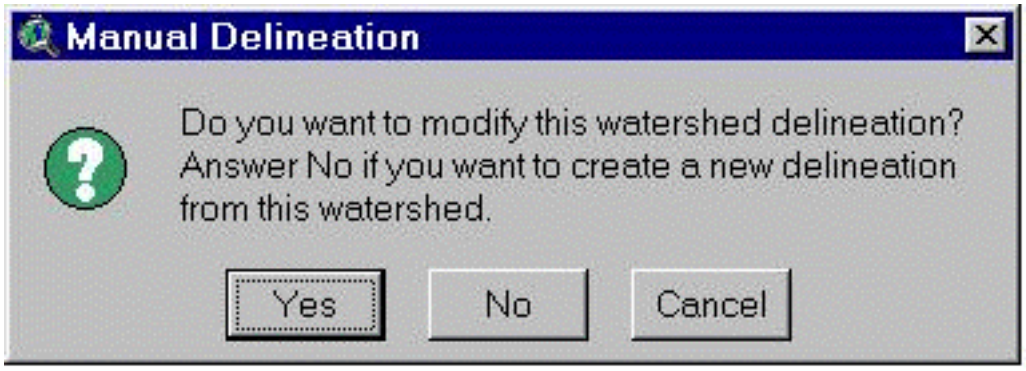
Tip: If the watershed is not delineated successfully, either the watershed boundary will not appear or the watershed boundary will appear with a warning window (Screen 8.1.11). If the watershed boundary appears along with a warning, it is necessary to immediately clean (delete) the watershed. Click *OK* to continue. Watershed cleaning is discussed after Multiple-Subwatershed Delineation.



Screen 8.1.11

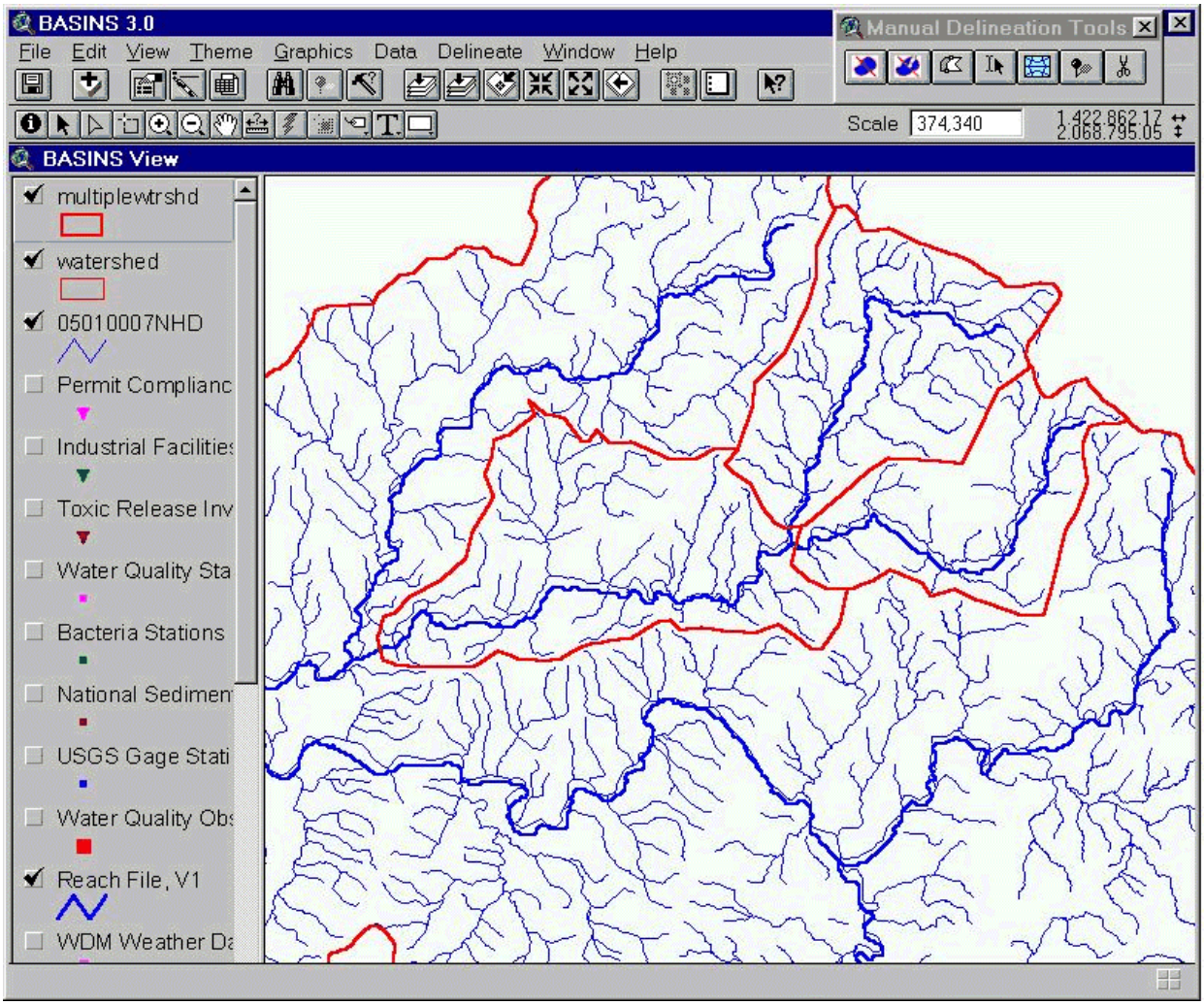
Multiple-Subwatershed Delineation

Multiple-subwatershed delineation lets you create and save a subwatershed system as a single shapefile. Subwatersheds in the system can be modeled and analyzed individually or as a group. Activate the watershed boundary theme created above or start a new watershed delineation using the cataloging unit theme. Click on the *Delineate Subbasin* button in the Manual Delineation Tools bar. If a user delineated watershed boundary theme is used, a dialog box will prompt: "Do you want to modify this watershed delineation?" (Screen 8.1.12). Answer *Yes* to continue the delineation on the existing watershed theme. Answer *No* to create a copy of the existing watershed boundary theme. This option allows you to alter a copy of the watershed delineation theme without making changes to the original theme.



Screen 8.1.12

Delineate a new watershed boundary using the methods described above for a single watershed delineation. After completing a watershed delineation for the first subwatershed, you will be asked: "Do you want to continue subwatershed delineation?" Select *Yes* (Screen 8.1.9). Begin delineation of the second subwatershed in the same manner as the first. For this delineation and subsequent subwatershed delineations, you can begin and end at a cataloging unit boundary or the boundary of a previously delineated subwatershed (in the same shape file; i.e., the present subwatershed system being delineated). Subwatersheds will automatically be clipped where they cross either the cataloging unit boundary or the outline of another subwatershed (Screen 8.1.13).



Screen 8.1.13

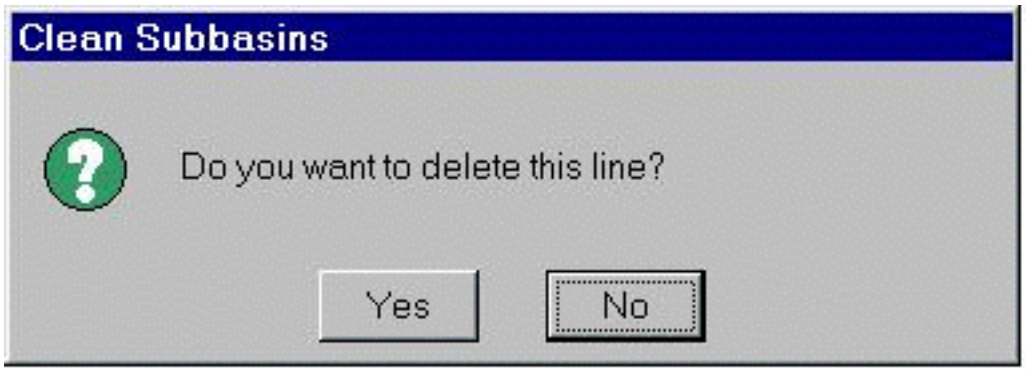
Respond by clicking *Yes* after each subwatershed delineation if you would like to continue delineating more subwatersheds. When you have completed the final subwatershed in the system, click *No*.

Tip: Additional delineations can be performed using an existing watershed theme. Activate the appropriate theme and select the BASINS *Watershed Delineation* tool. A window will appear (Screen 8.1.12). Click *Yes* to delineate additional subwatersheds in the current watershed theme. Click *No* to create a new watershed shape file. Click *Cancel* to exit delineation. The remaining steps are similar to those discussed above.

Watershed Cleaning

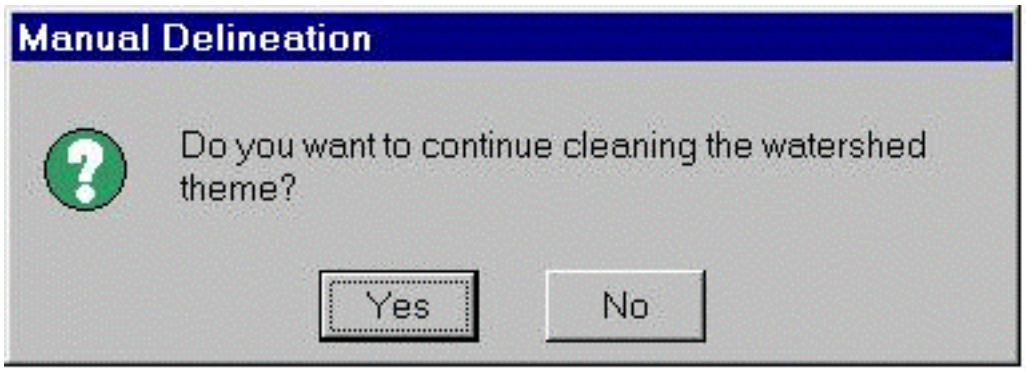
In many situations, it is necessary to delete a watershed or subwatershed or edit the watershed boundaries that have been delineated improperly. The *Clean Subbasins* tool and the *Edit Subbasin Boundaries* tool within the Manual Delineation Tools bar can be used to delete or edit a previously created watershed.

Clean Subbasins Turn on and activate the appropriate watershed theme. Click on the *Clean Subbasins* tool within the Manual Delineation Tool bar (Screen 8.1.4, second button). Select the watershed boundary segment you wish to delete. A window will ask if you want to delete the line (Screen 8.1.14). Click *Yes* to delete the line. Note the selected watershed boundary is deleted.



Screen 8.1.14

After deleting the watershed, you will be asked if you would like to continue cleaning (Screen 8.1.15). If you wish to clean additional watersheds associated with the watershed theme, click *Yes*. If you are finished cleaning the watershed theme, click *No*.

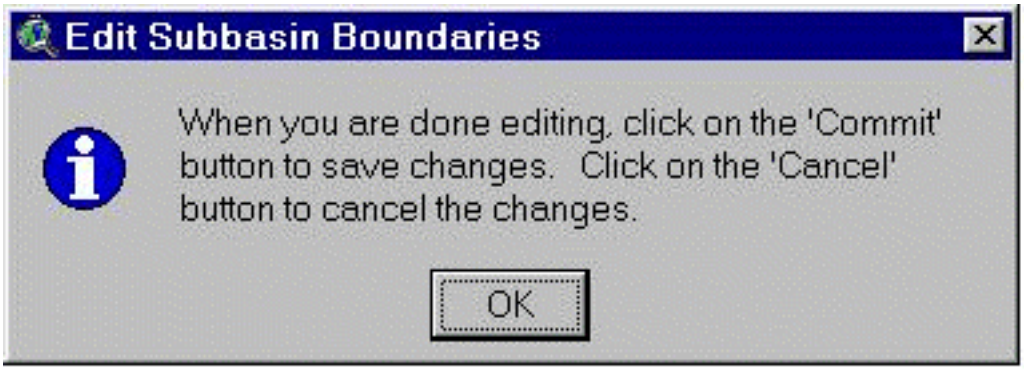


Screen 8.1.15

Tip: If an unsuccessful delineation warning (Screen 8.1.11) continues to appear after clearing and trying to continue the watershed delineation, review the theme view and attributes table to make sure no small polygons (defective subwatersheds) were inadvertently created during the delineation. These polygons may not be visible until you zoom in on the view. Use the cleaning

tool to remove any small polygons.

Edit Subbasin Boundaries Turn on and activate the appropriate watershed theme. Click on the *Edit Subbasins Boundaries* tool within the Manual Delineation Tool bar (Screen 8.1.4, third button). A message box will show up asking to click on the *Commit* button to save changes or click on the *Cancel* button to discard changes (Screen 8.1.16). Click on *OK*. Note that the Manual Delineation Tool bar is now in editing mode and has two extra buttons, the *Commit* and *Cancel* button (Screen 8.1.17). It is suggested that no other operation other than zooming (in or out) or panning be done during edit mode.



Screen 8.1.16

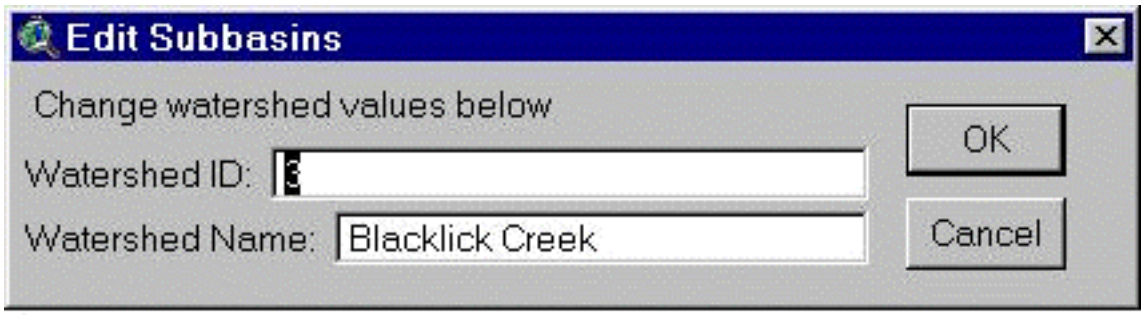
Screen 8.1.17

On clicking *OK* the mouse pointer changes shape and ArcView is now in its standard Vertex edit mode. To learn more about vertex editing inside ArcView see the ArcView help file on Editing a Theme > Editing Polygon Themes > Reshape Polygon Features. Select the watershed boundary segment you wish to edit. Notice that upon clicking, square shaped edit handles appear and can be moved to further refine the shape of the watershed boundary. Click on the *Commit* button when done editing to save changes or on the *Cancel* button to discard any changes (Screen 8.1.17).

Tip: When editing watershed boundaries it is important to select a shared common boundary to edit. ArcView's vertex edit works correctly only for shared common boundaries. If an outside boundary line is selected ArcView recognizes it as a single polygon and all the vertices on the polygon will have square edit handles. Editing this will create overlapping polygons which is not desirable. Upon selecting a shared boundary segment, the boundary gets selection handles (squares) and two end handles which are circles. The user is referred to the ArcView help for more information on Vertex Editing.

Edit Subbasin Name and ID

Upon delineation the sub watershed is automatically assigned a name and ID number based on the main stream within the particular subbasin. The user has the option to manually edit the subwatershed name and/or ID number. Turn on and activate the appropriate watershed theme. Click on the *Edit Subbasins IDs* tool within the Manual Delineation Tool bar (Screen 8.1.4, fourth button). Click on the watershed of interest. An Edit Subbasins dialog box will pop up (Screen 8.1.18). Notice this dialog box has two options, one for the Watershed ID and the other for the Watershed Name.



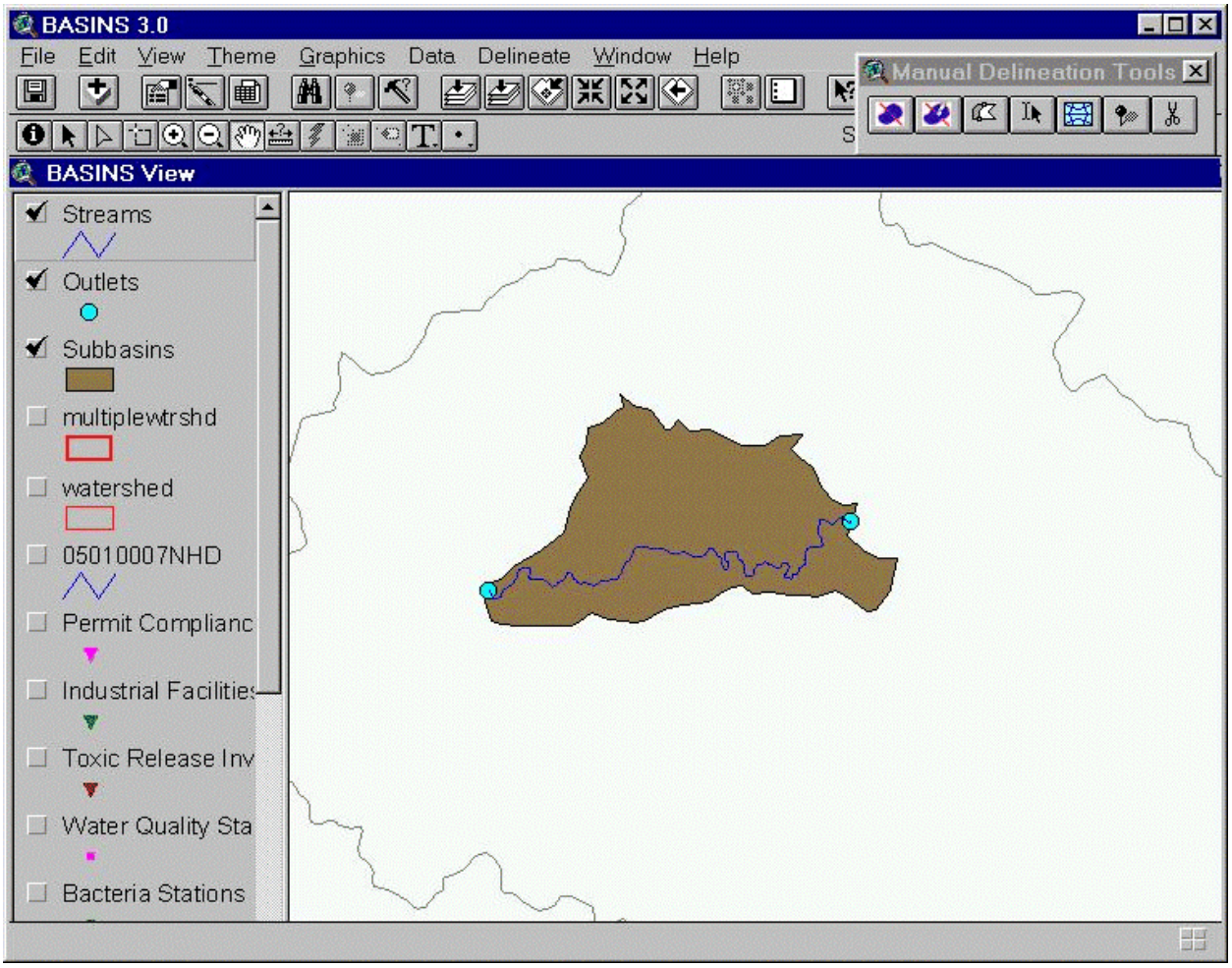
Screen 8.1.18

Make changes as necessary or observe the name and ID of the watershed. When finished click on *OK* to save changes or click on *Cancel* to discard changes.

Stream Network Definition and Outlet Points

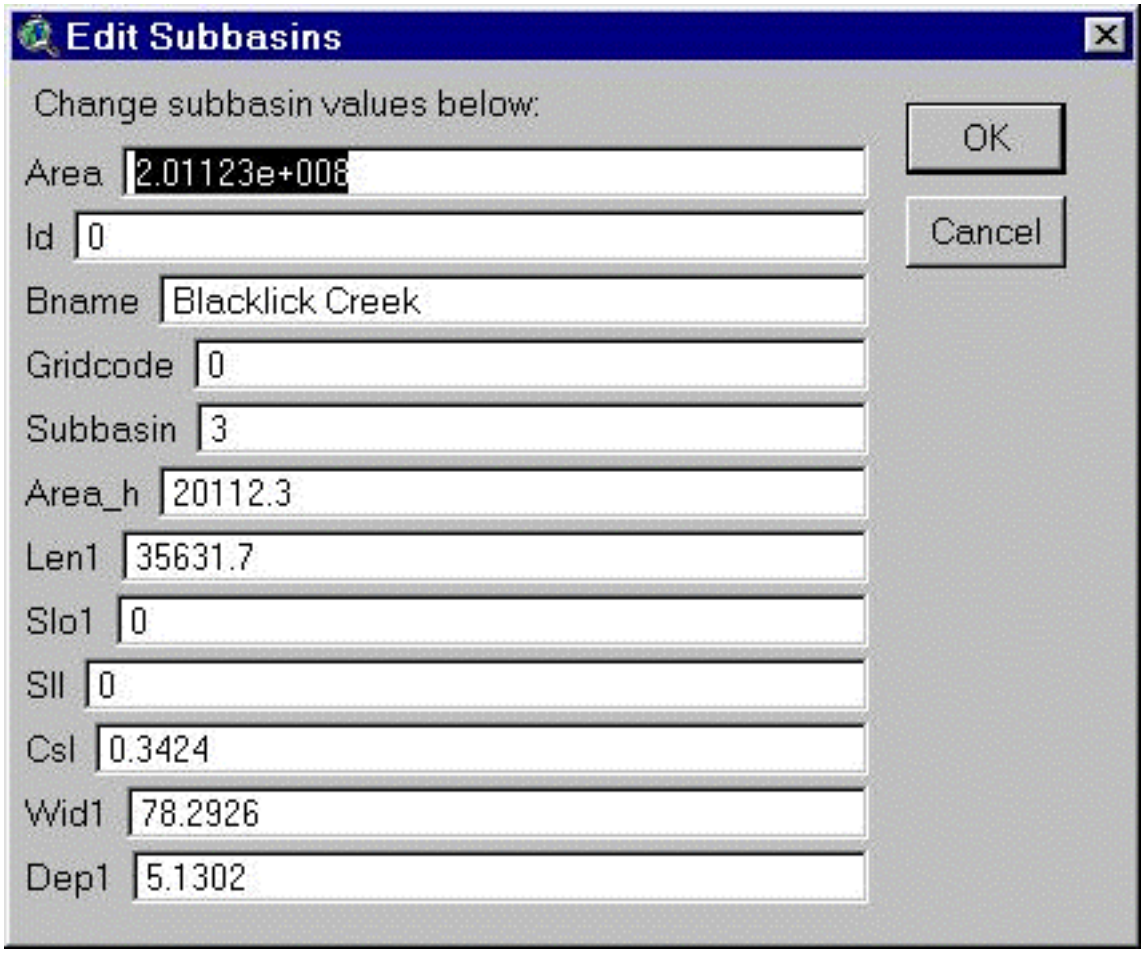
The Manual Delineation Tool bar provides the additional functionality of automatically defining the stream network and adding the subasin outlets. The user has to run the Stream Network Tool to generate three themes, the - Streams, Outlets and Subbasins themes, which are used for modeling purposes. The previously delineated watershed(s) can be used for watershed characterization.

Stream Network Turn on and activate the appropriate watershed theme. Select the watershed(s) for which the steam network is to be defined. Click on the *Stream Network* tool within the Manual Delineation Tool bar (Screen 8.1.4, fifth button) to start the processing of the watershed and stream network generation. Note three themes are created. Make the themes active to see the drainage network, delineated basin and outlet points of the watershed (Screen 8.1.19).



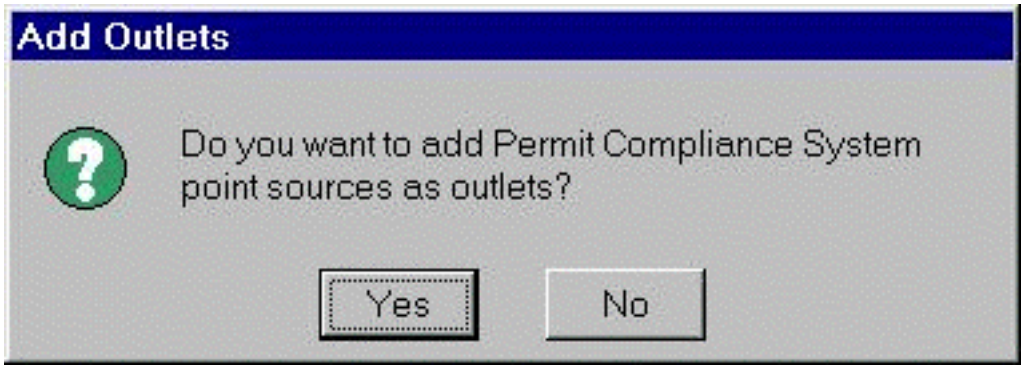
Screen 8.1.19

Tip: Note the Subasin theme generated has additional attributes appended to it. These attributes can be edited and viewed by making the Subbasin theme active and using the *Edit Subasins ID* tool button within the Manual Delineation Tool bar. These attributes are used as input to the model(Screen 8.1.20). A description of the attributes for the three themes can be found in Appendix A.



Screen 8.1.20

Manually Adding Outlets Turn on and activate the Outlets theme created from the stream network generation. Click on the *Add Outlets* tool within the Manual Delineation Tool bar (sixth button). A message box will show up. Click on *Yes* to add Permit Compliance System point sources as outlets for the watershed or *No* to manually add an oulet point (Screen 8.1.21).

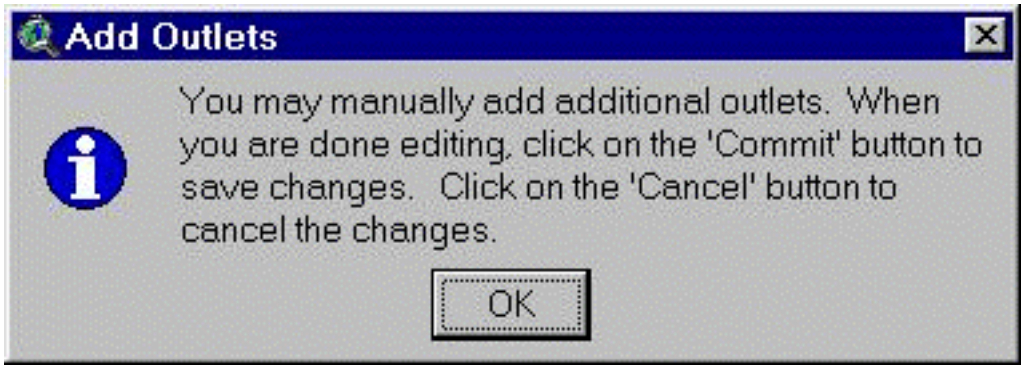


Screen 8.1.21

Click on *Yes* to add all the PCS data or click on *No* if you do not want to add the PCS data.

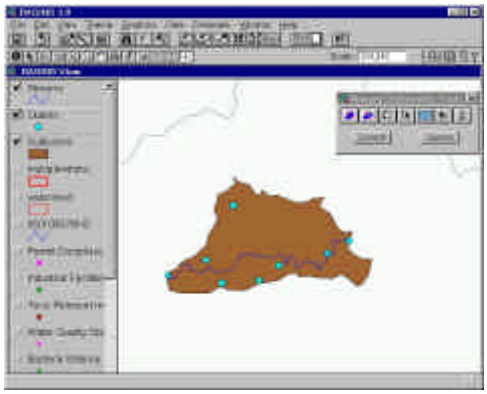
Tip: Note that at this point the Outlets theme has a dashed outline indicating it is in edit mode. Also the Manual Delineation Tool bar has two extra buttons the *Commit* and *Cancel* button.

A message box will show up asking to *Commit* the changes or click *Cancel* when done. Click on *OK* after reading the message, to start editing (Screen 8.1.22). Notice that the mouse pointer will change to a cross hair as it is in editing mode.



Screen 8.1.22

Click on the location where the additional outlet points need to be defined. The Outlet points will be added as you click on the location on the view (Screen 8.1.23)



Screen 8.1.23

Click on *Commit* when done to save changes or *Cancel* to discard changes.

Manually Deleting Outlets Turn on and activate the Outlets theme created from the stream network generation Click on the *Delete Outlets* tool within the Manual Delineation Tool bar (seventh button). A message box will show up asking to *Commit* the changes or click *Cancel* when done (Screen 8.1.24). Click on *OK* after reading the message, to start editing. Notice that the mouse pointer will change to a cross hair as it is in editing mode.

Screen 8.1.24

Tip: Note that at this point the Outlets theme has a dashed outline indicating it is in edit mode. Also the Manual Delineation Tool bar has two extra buttons the *Commit* and *Cancel* button.

Click on the Outlet points to delete the Outlet points that are not required. Click on *Commit* when done to save changes or *Cancel* to discard changes.

TUTORIAL:

Import the NHD theme: 05010007 and the DEM theme: 05010007.

Zoom in on Cataloging Unit # 05010007. Either the DEM or the NHD theme can be used as an aid in delineation. Use the NHD reach file for this exercise.

Turn on theme Cataloging Unit Boundaries theme.

Select Cataloging Unit # 05010007.

Assign the name watershed to your delineation.

Save the file in the BASINS\DATA\[PROJECTNAME]\WATERSHED\[PROJECTNAME]\SHAPES\ directory.

Zoom in further, so that Reach File Version 1 segments 05010007012, 05010007013, and 05010007014 are visible and cover most of the screen.

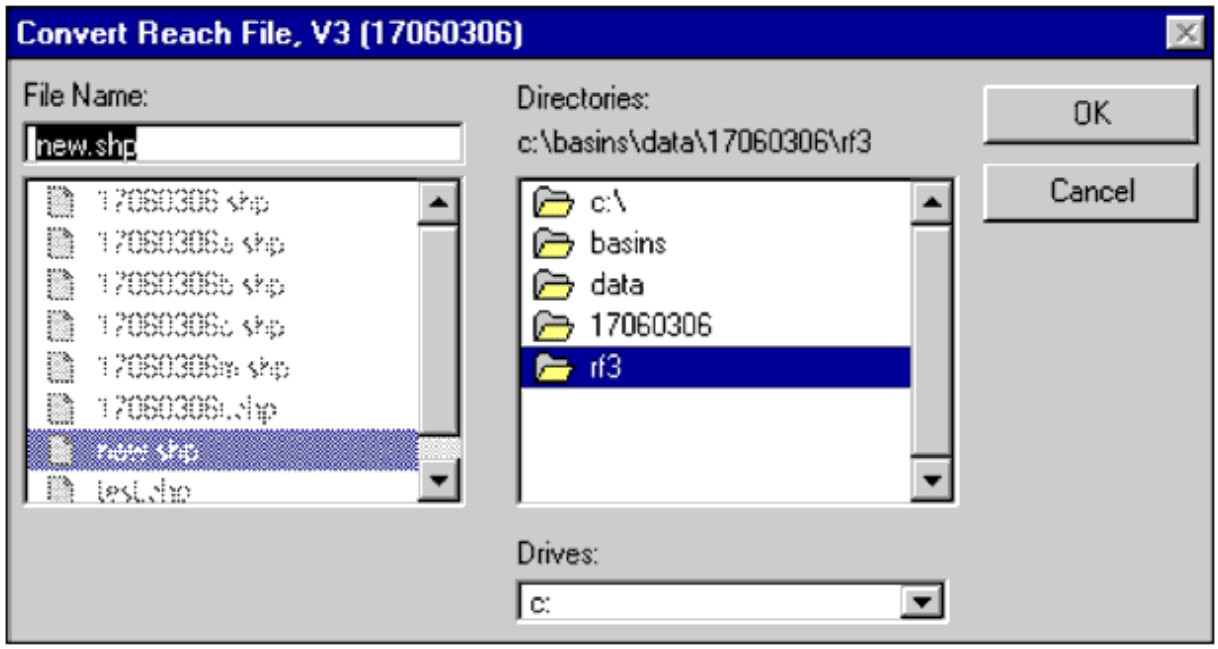
Delineate a watershed for all tributaries feeding into Reach File Version 1 segment 05010007014. Select *Yes* to continue delineation.

Add additional subwatersheds to the watershed.shp delineation for segments 05010007012 and 05010007013.

Select *No* to end delineation after completing a subwatershed for each of these three segments.

Watershed Delineations using Pacific Northwest Reach File Data

Stream reach data included in BASINS for the Pacific Northwest (PNW) region of the United States requires additional data processing before a watershed can be properly delineated and modeled. The PNW reach data is based on River Reach File, Version 2.1 specifically developed for this region. Data processing described below assist in simulating PNW reach file data in a manner similar to Reach File, V3. Imported PNW reach data as a Reach File, V3 theme using the BASINS *Import* Tool. Procedures for importing Reach File, V3 data are presented in section 7.3. Activate the PNW reach theme and select all stream reaches within a study area. Also select the downstream reach just beyond the study area. Once all stream segments are selected, choose Convert to Shapefile... from the Themes menu to convert these stream reaches into their own shapefile. In the dialog box that appears, enter a file name for the reach file theme to be created. Save the file to the BASINS RF3 directory to make this file easy to find when needed (Screen 8.1.25).



Screen 8.1.25

The next dialog box will prompt to "Add shapefile as theme to the view", select *No*. The theme can not be directly added to a view because it needs to be "tagged" as a Reach File, V3 theme to properly function with BASINS GIS functions and modeling. This is accomplished by re-importing the new theme as a BASINS Reach File, V3 theme. Import the new PNW theme using the BASINS *Import* tool (Refer to section 7.3). Turn off the original reach theme to clearly display the new theme in the view. Once the new theme has been imported, the stream network has to be developed using the following steps below. The PNW reach data contains many stream reaches with multiple line segments. A reach is defined as the portion of a stream between two tributaries or the headwaters to the first confluence. A reach must contain a single segment to properly function with BASINS GIS tools and models. Use the

Select Feature tool to identify reaches that include multiple segments. The multiple segments of a reach need to be merged to form a reach with a single segment.

- Select all segments within a single reach.
- From the Themes menu, select Start Editing
- From the Edits menu, select Union Features. The multiple segments will be merged into on segment.
- Select the segments in the next reach to be merged.
- Select Union Features from the Edit menu.
- Select Stop Editing from the Themes menu. Choose *Yes* when prompted to save changes to theme.
- Repeat steps e to g until all reaches contain a single segment.
- View the attributes table for this theme to confirm that all reaches contain a single segment. The number of records (rows) in the attributes table should correspond to the proper number of reaches (single segment reaches) in the theme.

Assign a stream order to the network using the steps described below. Stream order is used to define the connectivity of the stream network which is required for modeling. As shown in Figure 8.1, this method is based on an increasing stream ordering number from downstream to upstream. In this example, Blacklick Creek is assigned a stream level of one for its entire length. All tributaries that discharge directly to Blacklick Creek are assigned a two. For example, Elk Creek is a second order stream. All tributaries directly discharging to Elk Creek are then assigned a three. The process continues to the upper most reach. Note that at a confluence the main stream channel identified by name (i.e., Blacklick Creek) in the reach file database is assigned the same stream level for its upstream and downstream segments.

- Activate the new RF3 theme's attribute table. From the Windows menu, select Tile to display the attributes table and BASINS view together.
- With the attributes table active, select Start Editing from the Table menu.
- Select *Add Field* from the Edit menu. A Field Definition dialog box will appear (Screen 8.1.26). Enter the parameters for the Name, Type, Width and Decimal Places fields according to the values shown in Screen 8.1.26. Select *OK* to continue. A new field labeled "Level" will be created in the table.

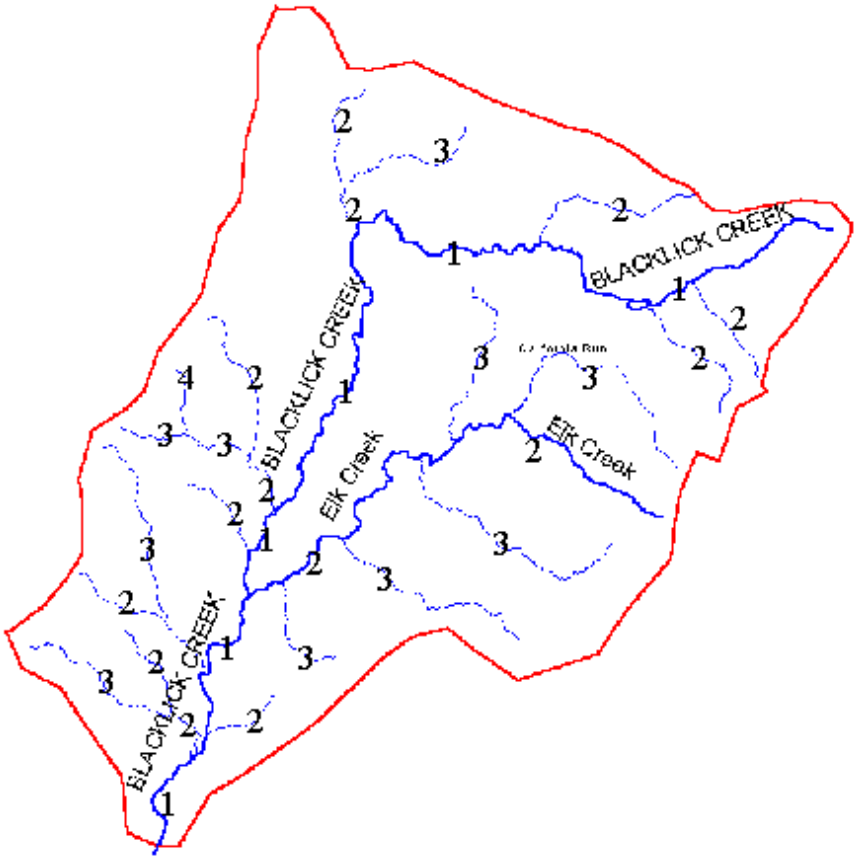
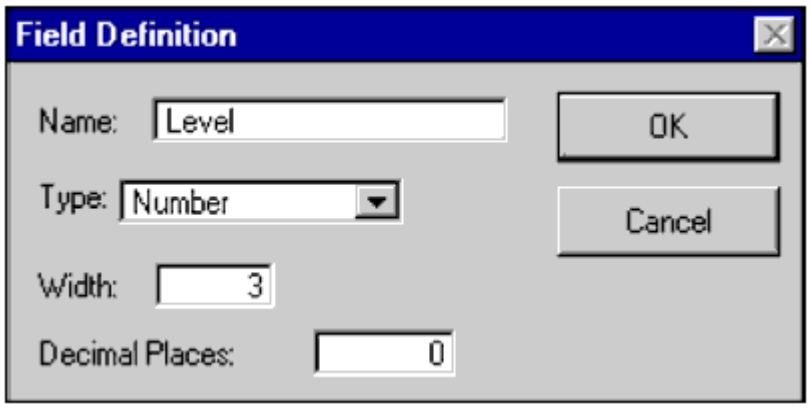
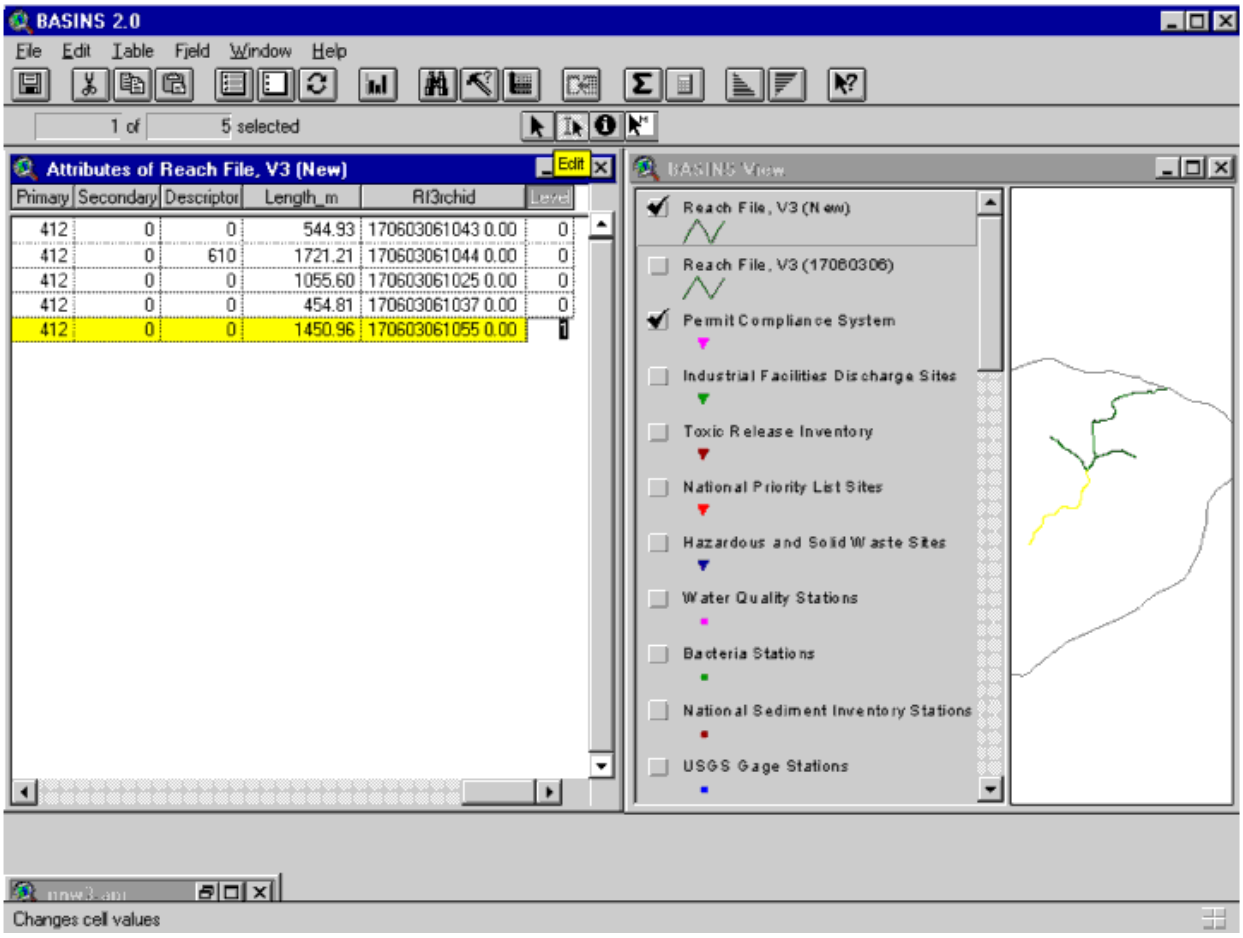


Figure 8.1



Screen 8.1.26

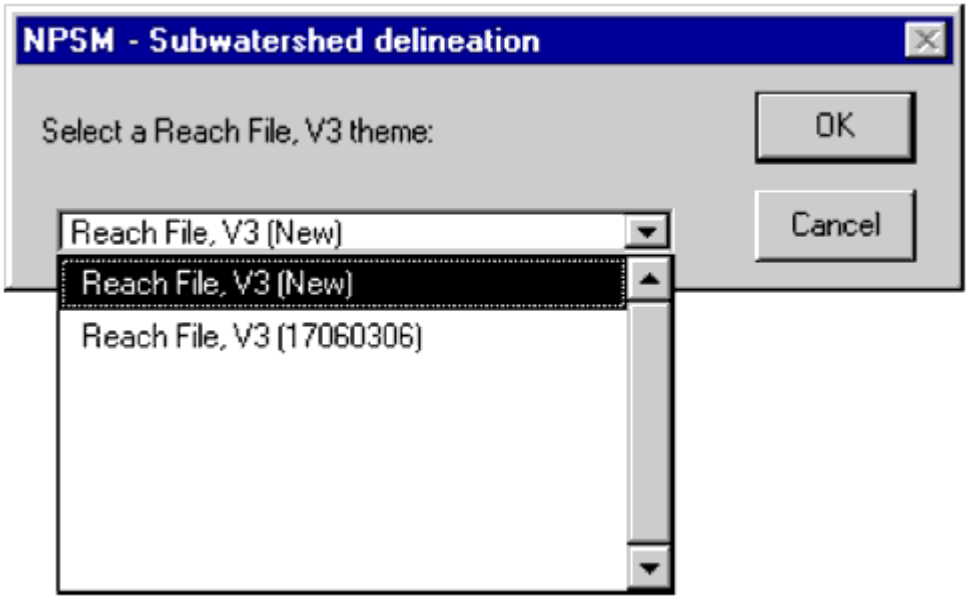
- With the attribute table still in edit mode, return to the BASINS view and select the downstream reach in the new RF3 theme. The record that corresponds to this reach will also become selected in the table.
- Return to the attributes table to enter an order number in the new "Level" field for this stream reach. A number is entered into the "Level" field by selecting the *Edit* button from the button bar and using the mouse to click on the record in the level field (Screen 8.1.27).
- Repeat steps d and e until every reach is assign an order number. Proceed from downstream to upstream reaches to help properly assign stream order.
- Select Stop Editing from the Table menu. Choose *Yes* when prompted to save changes to theme.



Screen 8.1.27

The new theme containing the PNW reach file data is now ready to be used for watershed delineation and subsequent watershed characterization functions and modeling. Follow the watershed delineation methods discussed previously in this section. When prompted to select a Reach File, V3 theme, select the

new RF3 theme and follow the standard watershed delineation procedures (Screen 8.1.28).



Screen 8.1.28